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Effects of floor space on the productivity of broilers in the wet humid tropics of South Western Nigeria

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ABSTRACT

Six different floor spaces, each was allotted for 4 birds in cells: F_1A (2,000cm^2), F_2A (2,200cm^2), F_3A (2,400cm^2), F_4A (2,600cm^2), F_5A (2,800cm^2), F_6A (3,000cm^2). Birds housed in each of cells of floor areas: S_1A (2,400cm^2) = 4, S_2A (4,200cm^2) = 6, S_3A (5,600cm^2) = 8, S_4A (7,000cm^2) = 10. Each was replicated thrice. Results revealed that effects of pen floor areas were significant on bird's weight of 1482±5.07 g. There were discrepancies in birds' final weights (range: 1218±2.03 to 1482±5.07 g), however, 2800cm^2 pen showed nearly uniform birds' weights. Average birds' feed intakes (range: 5541g±11.30 to 5588g±14.06 g) were high in 2,800cm^2 and 3,000cm^2 with fluctuations recorded in feed conversion ratio in all pens, except cell 2,800cm^2. Stocking density had significant effect on the bird's meat quality; 2,800cm^2 pen of four birds with 700cm^2 per bird was hereby recommended for high broiler's performance.

Key words: Feed conversion ratio, Floor geometry, Stocking density

In enhancing maximum performance of broilers reared in the tropics, there must be positive correlation between the floor space area and the number of birds kept (Sara and Michael 2013, Adebiyi *et al*. 2011, Lamidi 2005). The objectives of the research were to examine effects of stocking density on performance and productivity of broilers to determine the best floor space for specific number of birds that would enhance their productivity in wet warm humid climate.

MATERIALS AND METHODS

Stocking density of birds: Six different pens' geometries F_1A = 2,000 cm^2, F_2A = 2,200 cm^2, F_3A = 2,400 cm^2, F_4A = 2,600 cm^2, F_5A = 2,800 cm^2, and F_6A = 3,000 cm^2, housed four birds each under the same conditions. The above signified the floor geometries of 0.05 m ^{2}, 0. 055 m ^{2}, 0.06 m^2, 0.065 m ^{2}, 0.07 m ^{2} and 0.075 m ^{2} respectively per bird in each pen. There were 3 replicates each for an arrangement making the total number of pens to be 18 with 72 birds. The replicates in F_1A are pens F_1A_1, F_1A_2, F_1A_3, etc and in F_2A are pens F_2A_1, F_2A_2, F_2A_3, where F_1A, F_2A, are called cells and F_1A_1, F_1A_2, F_2A_1 are referred to as pens in the study. Also, for the second experiment, 4 birds each were housed in 2,400 cm^2, 6 birds in 4,200 cm^2; 8 birds in 5,600 cm^2 and 10 birds in 7,000cm^2 floor areas. The replicates in S_1A are S_1A_1, S_1A_2, S_1A_3, etc and in S_2A are S_2A_1, S_2A_2, S_2A_3, where S_1A, S_2A, are called cells and S_1A_1, S_1A_2, S_2A_1 are referred to as pens, Table 2. Each of the day-old chicks were weighed and tagged with letters as above for identification.

Experimental design: A total of 156 birds in 30 pens in a completely randomised block design experiment to checkmate influence of like pens over each other (RSPCA 2013, Sara and Michael 2013). All the pens were placed in their different places with the housing measurement through engineering equipment, the whole building used (where the pens were constructed) was subjected to survey for its existing orientation to the direction of the wind and its subsequent aeration for proper documentation and analysis to see whether it was of standard. The birds were all treated equally during rearing in deep litter housing with water absorbent materials flooring. An existing building of deep litter housing of internal features minimum to permit maximum straight-through ventilation of the house with water absorbent floor materials was used in the south western Nigeria city of Ile-Ife on latitude 07° 28' N and longitude 5° 33' E. Since the birds were confined, they were subjected to greater environmental control to promote highest level of performance. The experiment was performed in the rainy season.

Feeding and management of experimental birds: The birds were fed with corn, soy beans, bone meals and other necessary feed ingredients diets, they were fed *ad lib.* with broiler starter 0–4 weeks and finisher ration into 8 weeks with the same amount of feed and water for each bird. The feed troughs were full always up to two-third depth. The

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left over if any at all, were weighed weekly to know the actual kilogrammes of feed consumed/pen/broiler.

The body weight gain of the broilers during the interval of a week was the difference between the previous week's weight and the current week's weight (Alaeldein *et al*. 2013). This was used to determine the meat yield (carcass yield) and weekly weight gain. The average growth rates were calculated over specific periods and are the cumulative weight of birds/unit period of time. In this case, it was cumulative live weight/unit age of birds as used in the research. The percent carcass yield as given by Crawford (1990) is

$$\frac{W_C}{W_l} \times 100\%$$

where W_c, carcass weight and W_l, chicken live weight.

The weekly cumulative feed intakes and live weight of each bird were used in the calculation of feed conversion ratio (FCR). The effectiveness and efficient use of feed by broiler is referred to as feed efficiency (FE) and is defined as the reciprocal of feed conversion ratio, it normally decreases with increase in bird's age (Crawford 1990), FCR is given by Crawford (1990) as:

$$\frac{F_d}{W_l} = FCR$$

where F_d, grammes of feed consumed by broiler; W_l, live weight of broiler and

$$\frac{1}{FCR} = FE$$

For the quality of the broiler's meat, 50% of the birds were killed in each pen for the meat quality assessment through proximate analysis to determine the amount of moisture, protein, ether extract (lipid), crude fibre and ash contents, the addition of all these, when subtracted from 100% gives the crude fibre or carbonhydrate content. Their average values per pen were recorded and used in statistical analysis.

RESULTS AND DISCUSSION

Feed intakes and feed conversion ratio (FCR): There were variations in feed intakes of a broiler, Table 1, these variations were more in the bird's feed intakes in F_1A = 2,000 cm^2, F_2A = 2,200 cm^2 and F_6A = 3,000 cm^2, [(145.3, 146.3, 146.7 g) and (308, 309.7, 309.2 g)] , respectively, for the first 2 weeks; these were not as much felt in 2400 cm^2, 2600 cm^2 and 2800 cm^2 [(145.8, 148, 148 g) and (308.3, 307.9, 310 g)], respectively, for the first 2 weeks. Feed conversion ratios per bird were significantly affected ($P < 0.05$) by all floor space areas. For instance, floor spaces 2,000 cm^2 and 3,000 cm^2 were significantly affected ($P < 0.05$). The graphical analysis of feed conversion ratio with birds' age at constant bird stocking density with varying floor spaces is given in Fig. 1. Results showed that 2,800cm^2 and 3,000cm^2 (F_5A and F_6A) have increasing FCR values (Table 2, 3), others have low values at some weeks than the preceding one within the 8 weeks period. Birds in such floor spaces having fluctuating FCR within weeks could be due to effects of floor geometries and birds' density, which could have resulted in their crowdedness. FCR normally increases with increase in birds' age (Tables 2, 3); otherwise factors like climatic conditions, management, breed and others, when unfavourable could have caused upset.

The results of feed conversion at varied floor space and constant stocking densities and at varied stocking densities and constant floor space are, respectively, shown in Figs 1 and 2 with their equations and R^2 values in Tables 5 and 6. It can be seen that while FCR increases with broilers' age as suppose, there were decreases in some of the pens (Figs

Table 1. Mean values of feed conversion ratio and feed efficiency of broilers under varying floor space constant stocking density

Cell	Feed conversion ratio, dimensionless									
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Cum. Fd, g	Cum. Wt, g
F_1A	$1.95^{c}\pm0.06$	$3.13^{b}\pm0.02$	$3.00^{b}\pm0.01$	$3.03^{b}\pm0.01$	$3.41^{a}\pm0.02$	$4.88^{c}\pm0.05$	$5.20^{d}\pm0.03$	$5.75^{bc}\pm0.13$	$5551^{d}\pm10.03$	$1392^{b}\pm16.07$
F_2A	$1.94^{c}\pm0.02$	$2.97^{c}\pm0.03$	$3.11^{a}\pm0.20$	$2.75^{d}\pm0.18$	$3.30^{b}\pm0.01$	$5.07^{b}\pm0.08$	$5.45^{b}\pm0.43$	$7.66^{a}\pm0.44$	$5541^{e}\pm11.30$	$1342^{d}\pm13.08$
F_3A	$1.99^{b}\pm0.21$	$3.58^{a}\pm0.03$	$2.66^{d}\pm0.03$	$2.81^{c}\pm0.05$	$3.20^{c}\pm0.02$	$5.62^{a}\pm0.03$	$5.35^{c}\pm0.03$	$6.76^{b}\pm0.03$	$5584^{b}\pm12.03$	$1382^{c}\pm12.04$
F_4A	$1.94^{c}\pm0.01$	$2.88^{d}\pm0.02$	$2.86^{c}\pm0.04$	$2.79^{d}\pm0.01$	$3.28^{b}\pm0.24$	$4.97^{c}\pm0.05$	$5.53^{a}\pm0.33$	$6.42^{c}\pm0.33$	$5571^{c}\pm7.04$	$1407^{ab}\pm11.03$
F_5A	$2.08^{a}\pm0.02$	$2.69^{ab}\pm0.04$	$2.87^{c}\pm0.06$	$3.05^{b}\pm0.07$	$3.05^{d}\pm0.05$	$4.35^{e}\pm0.05$	$4.80^{e}\pm0.13$	$5.63^{d}\pm0.03$	$5573^{ab}\pm10.01$	$1480^{a}\pm 5.72$
F_6A	$1.99^{b}\pm0.05$	$2.55^{cd}\pm0.22$	$2.62^{d}\pm0.11$	$3.16^{a}\pm0.01$	$3.28^{b}\pm0.15$	$4.64^{d}\pm0.17$	$5.35^{c}\pm0.03$	$6.27^{ab}\pm0.53$	$5588^{a}\pm14.06$	$1408^{ab}\pm10.05$

Cell	Feed efficiency, dimensionless							
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
F_1A	$0.52^{a}\pm0.00$	$0.33^{bc}\pm0.02$	$0.34^{c}\pm0.01$	$0.34^{ab}\pm0.0$	$0.30^{d}\pm0.02$	$0.21^{ab}\pm0.02$	$0.19^{b}\pm0.03$	$0.17^{b}\pm0.01$
F_2A	$0.52^{a}\pm0.02$	$0.34^{b}\pm0.03$	$0.33^{ac}\pm0.0$	$0.37^{a}\pm0.06$	$0.30^{d}\pm0.01$	$0.20^{b}\pm0.01$	$0.18^{c}\pm0.01$	$0.13^{ac}\pm0.02$
F_3A	$0.50^{c}\pm0.01$	$0.29^{c}\pm0.10$	$0.38^{a}\pm0.03$	$0.36^{b}\pm0.00$	$0.32^{b}\pm0.02$	0.18 ± 0.03	$0.18^{c}\pm0.03$	$0.15^{ab}\pm0.03$
F_4A	$0.52^{b}\pm0.10$	$0.35^{b}\pm0.02$	$0.35^{b}\pm0.04$	$0.36^{b}\pm0.01$	$0.31^{c}\pm0.04$	$0.20^{b}\pm0.03$	$0.18^{c}\pm0.00$	$0.16^{c}\pm0.00$
F_5A	$0.49^{bc}\pm0.02$	$0.38^{ab}\pm0.14$	$0.35^{b}\pm0.16$	$0.33^{c}\pm0.00$	$0.33^{a}\pm0.00$	$0.23^{a}\pm0.00$	$0.21^{a}\pm0.10$	$0.18^{a}\pm0.03$
F_6A	$0.51^{ab}\pm0.04$	$0.40^{a}\pm0.01$	$0.38^{a}\pm0.12$	$0.32^{c}\pm0.01$	$0.30^{d}\pm0.01$	$0.21^{ab}\pm0.01$	$0.18^{c}\pm0.03$	$0.16^{c}\pm0.02$

Cum. Fd, cumulative feed intake per broiler; Cum. Wt, cumulative weight gain per broiler; ^{a,b,c,d}Means with the same letters along the same column are not significantly different ($P < 0.05$).

Table 2. Mean values of feed conversion ratio and feed efficiency of broilers under varying stocking densities constant floor space

Cell	Feed conversion ratio, dimensionless									
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Cum. Fd, g	Cum. Wt, g
S_1A	2.11^a±0.06	2.72^c±0.02	3.18^a±0.01	3.00^{ab}±0.01	3.13^d±0.02	4.46^d±0.05	4.90^d±0.03	5.44^d±0.13	5583^a±12.3	1482^a±5.07
S_2A	2.00^b±0.02	2.75^{ab}±0.03	3.15^b±0.20	2.76^c±0.18	3.44^c±0.01	8.15^a±0.08	7.76^a±0.43	7.49^b±0.44	5581^b±9.30	1227^b±3.17
S_3A	2.00^b±0.21	2.86^a±0.03	2.95^c±0.03	3.70^a±0.05	3.86^a±0.02	6.03^b±0.03	6.80^b±0.03	7.02^c±0.03	5583^a±10.03	1224^c±6.04
S_4A	1.97^a±0.01	2.79^b±0.02	2.91^d±0.04	3.62^b±0.01	3.62^b±0.24	5.94^c±0.05	6.37^c±0.33	7.73^a±0.33	5579^c±6.14	1218^d±2.03

Cell	Feed efficiency, dimensionless							
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
S_1A	0.48^c±0.00	0.37^a±0.02	0.32^b±0.01	0.37^a±0.01	0.32^a±0.02	0.23^a±0.02	0.21^a±0.03	0.18^a±0.01
S_2A	0.50^b±0.02	0.37^a±0.03	0.32^b±0.00	0.36^b±0.06	0.30^b±0.01	0.13^c±0.01	0.13^{ab}±0.01	0.14^{ab}±0.02
S_3A	0.51^a±0.01	0.35^{ab}±0.10	0.34^a±0.03	0.27^c±0.00	0.27^{ab}±0.02	0.17^b±0.03	0.15^c±0.03	0.15^b±0.03
S_4A	0.51^a±0.10	0.36^c±0.02	0.31^c±0.04	0.25^d±0.01	0.28^c±0.04	0.17^b±0.03	0.16^b±0.00	0.13^c±0.00

Cum. Fd, cumulative feed intake per broiler; Cum. Wt, cumulative weight gain per broiler; [a,b,c,d]Means with the same letters along the same column are not significantly different ($P < 0.05$).

1, 2). Tables 5 and 6 shows their R^2 values, all pens have higher correlations ranging between 0.820 and 0.988 for both floor space and stocking densities variations or constant.

Birds' weight gains and weight uniformity: The graphical analysis of the broilers weight gains showed that floor space of 2,800 cm^2 per four birds has closest points than any other pens and there was no weight loss unlike other pens (Fig. 2). While all other pens fluctuate in growth rate, 2,800 cm^2 and 3,000 cm^2 were relatively exceptional. Their R^2 values also were the highest (0.988 and 0.984 respectively, Table 5) among others.

The range of birds' weight values was between 1.218 kg (the lowest in the research, recorded in 7,000 cm^2 pen for 10 birds) and 1.485 kg (the highest in the experiment, recorded in 2,800 cm^2 pen). Non-uniformities in growth among birds in the same pen were due to much different weight gains during the rearing periods. The mean values of number of birds kept in a pen of specific floor area, which is the bird stocking density, had significant effects ($P \leq 0.05$) upon the weight gain (broiler's meat yield). Cell 2,800 cm^2 of pens S_1A_1, S_2A_2 and S_3A_2 gave mean value that is

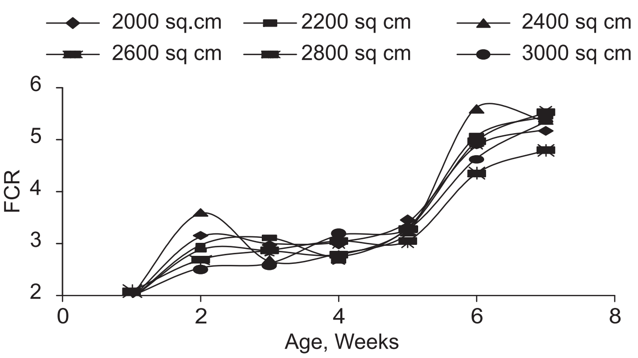

Fig. 1. Weekly FCR of broilers at varied floor spaces and same stocking densities.

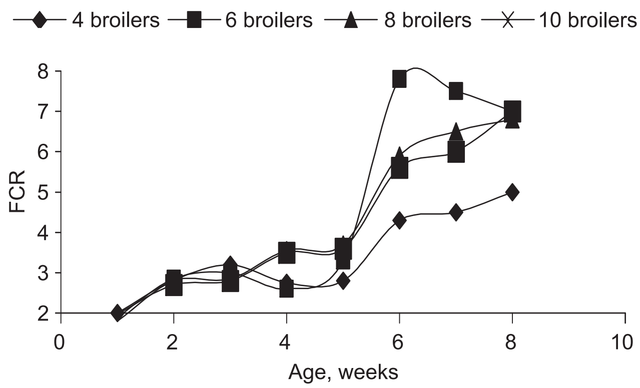

Fig. 2. Weekly FCR of broilers at varied stocking densities, constant floor space.

Table 3. Mean values of proximate analysis of floor space effects on broiler's meat quality

Floor Spaces, cm^2	Mean values* of proximate analysis,%				
	Crude protein	Ether extract	Moisture content	Ash content	Crude fibre
2000	19.88^{bc} ±0.63	0.58^{ba}±0.06	78.44^a±0.49	0.89^a±0.20	0.21^{bc}±0.09
2200	19.21^b±0.38	1.10^{bc}±0.07	77.95^a±1.42	0.80^{ab}±0.12	0.93^{ab}±0.92
2400	19.87^{bc}±0.22	1.19^b±0.20	77.57^{ab}±0.75	0.62^d±0.16	0.75^a±0.96
2600	19.29^c±0.46	1.01^{ab}±0.58	77.67^{ac}±0.75	0.75^a±0.22	1.28^a±0.66
2800	23.17^a±0.21	2.01^a±0.05	73.67^b±0.05	0.80^{ab}±0.05	0.35^{ac}±0.11
3000	21.26^b±1.88	0.94^b±0.41	77.63^c±0.64	0.72^c±0.08	0.38^c±0.33

*Means with the same letter along the same column are not significantly different, $P \leq 0.05$.

Table 4. Mean values of proximate analysis of stocking densities effects on meat's quality

Stocking densities	Mean values* of proximate analysis,%				
	Crude protein	Ether extract	Moisture content	Ash content	Crude fibre
4	$23.29^{a}\pm0.25$	$2.12^{a}\pm0.06$	$73.30^{c}\pm0.62$	$0.89^{a}\pm0.18$	$0.40^{c}\pm0.41$
6	$21.26^{b}\pm0.62$	$0.60^{b}\pm0.51$	$76.64^{b}\pm0.59$	$0.85^{ab}\pm0.29$	$0.64^{a}\pm0.62$
8	$20.01^{c}\pm0.27$	$0.67^{b}\pm0.14$	$78.10^{a}\pm0.52$	$0.72^{b}\pm0.07$	$0.50^{ab}\pm0.20$
10	$19.88^{ab}\pm0.10$	$0.91^{ab}\pm0.56$	$78.00^{ab}\pm0.00$	$0.72^{b}\pm0.08$	$0.50^{ab}\pm0.20$

*Means with the same letter along the same column are not significantly different, $P \leq 0.05$.

Table 5. Productivity of broilers at varying floor space, constant stocking density

Floor space, cm^2	Mortality	Significant on yield, g	Significant on meat quality	Weight uniformity	R^2weight	R^2FCR
F_1A	10%	S	S	Progressive	0.908	0.953
F_2A	Nil	S	S	Weight losses	0.897	0.890
F_3A	Nil	S	S	Progressive	0.751	0.850
F_4A	Nil	S	S	Progressive	0.930	0.869
F_5A	Nil	S	S	Progressive	0.946	0.988
F_6A	Nil	S	S	Progressive	0.974	0.984

statistically different at $P \leq 0.05$. The mean values groupings as shown in Table 4 gave significant main effect of floor space on birds' highest average growth rate 1.482 kg. Birds at maximum floor space of $0.07 m^2$/ bird (700 cm^2/ bird) in 2800 cm^2 for 4 birds have highest crude protein ($23.17^{a}\pm$ 0.21); ether extract ($2.01^{a}\pm 0.05$) and low moisture content ($73.67^{b}\pm 0.05$) of the meat at varying floor spaces, constant stocking density and therefore have highest meat quality (Tables 4, 5).

There were birds' weight losses in all the pens, the losses were higher in higher stocking densities, this brought about reduced liveweights and carcass weights as seen in Fig. 2, (Feddes *et al.* 2006). The reason was because there were seemingly more spaces than necessary for behavioural characters (like cob or feather peckings), sociological characters (like fighting) and psychological characters (like cannibalism) in higher floor area pens. Therefore, it could be opined that inabilities of birds in lesser floor areas/spaces to demonstrate those characters unnecessarily could have likely resulted in their moderate feeding, and therefore weight gains, than birds in higher floor areas/spaces. Also, while all other pens fluctuate in growth rate, 2,800 cm^2 and 3,000 cm^2 were relatively exceptional. Their R^2 values also were the highest (0.988 and 0.984 respectively, Table 5), among others.

Furthermore, the mean values groupings as shown in Table 4 gave significant main effect of floor space on birds' highest average growth rate 1.482 kg. There were non-uniformity in weight gain in each pen for their birds, but uniformities in weights were better at higher stocking densities than lower stocking densities Figs. 1 and 2. This finding agreed with Feddes *et al.* (2006) that weights' uniformities were better at higher stocking densities in broiler. The reason was because of the spaces (within the space provided) for behavioural, sociological and psychological characters. The more the birds showed these characters, the more they wasted energy that could have been used to build up needed carcasses. Ten birds given 7,000 cm^2 have 700 cm^2/ bird, a bird has to itself the whole

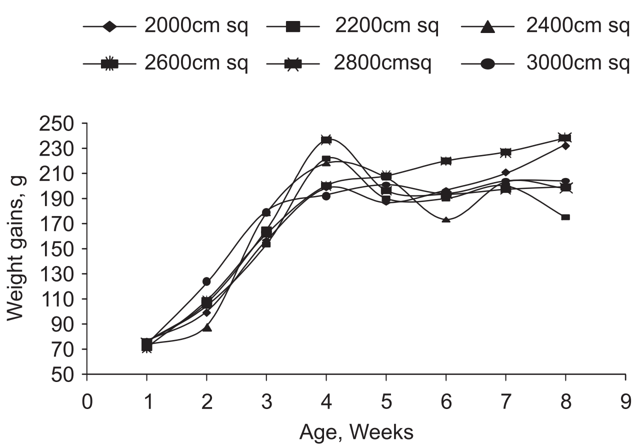

Fig. 3. Weekly average weight gains at varied floor spaces, constant stocking densities.

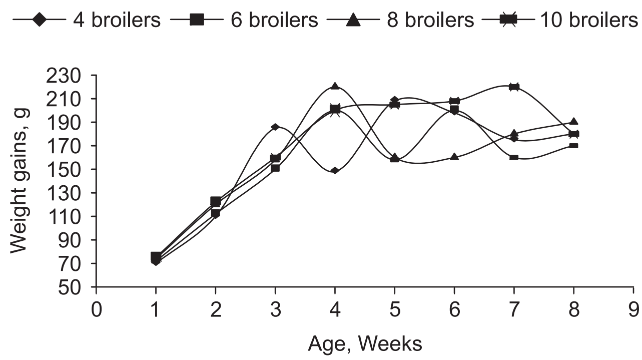

Fig. 4. Weekly average weight gains at varied constant stocking densities constant floor space.

Table 6. Productivity of broilers at varying stocking density, constant floor space

Stocking densities	Mortality	Significant on yield, g	Significant on meat quality	Weight uniformity	R^2weight	R^2FCR
S_1A	25%	S	S	Non uniformity	0.849	0.849
S_2A	Nil	S	S	Non uniformity	0.852	0.851
S_3A	Nil	S	S	Non uniformity	0.820	0.816
S_4A	20%	S	S	Non uniformity	0.981	0.981

S, Significance at $P \leq 0.05$; Wt, weight/yield of broilers.

area of 7,000 cm ^{2} to move round, thereby wasting energy needed for carcass or/ muscular buildings and developments, this happened in all other pens. Again, some birds become faster growing and stronger which eventually resulted in the domination of faster growing over slower growing, or stronger ones over weaker ones in the same pen. They overpowered them in activities like in feeding, drinking and the cycle continues. This also likely could have led to non-uniform weights found in the birds (Figs. 2 and 3).

Broilers' meat quality: Birds at maximum floor space of 0.07m^2/ bird (700 cm ^{2}/ bird) in 2,800 cm ^{2} for 4 birds have highest crude protein (23.17 ^{a}± 0.21); ether extract (2.01 ^{a}± 0.05) and low moisture content (73.67 ^{b}± 0.05) of the meat at varying floor spaces, constant stocking density and therefore have highest meat quality (Tables 3, 4). Thus a maximum of 700 cm^2 space/bird could be needed for good performance in a broiler in tropical countries and that chickens' welfares are influenced more by housing conditions more than stocking densities (RSPCA 2013, Sara and Michael 2013, Lamidi 2005, Dawkin *et al*. 2004). Again, it was revealed that the effects of floor geometries and birds density were significant on the carcass quality of broiler at $P \leq 0.05$ level. The mean values of proximate analysis of floor space effects on meat quality from Tables 3 and 4 showed that crude protein and ether extract of the meat were statistically different from one another, whereas the mean values for moisture content, ash content and crude fibre were not statistically different at both floor spaces and stocking density effects.

Mortality rate: S_4A with 10 birds had higher mortality compared to other pens (only S_1A pen was excluded), thus, during rearing, at higher stocking density, mortality rate of broilers could be higher. Coccidiosis was noticed at the end of their third week in pen S_4A_2, despite due care been quickly taken to prevent spread, it was due to high stocking density, 6 birds were recorded dead. Two birds each in pens S_4A_1 and S_4A_2, (that is, 20%) and one bird each in pens S_1A_1, and S_1A_2, (25% mortality rate) (Tables 5, 6). Mortality rates expressed as ratio of dead bird in a cell to the total number of bird in a cell were 0% in all other cells except S_4A and S_1A.

Birds in S_1A and S_4A showed respectively 25 and 20% mortality rates impling that stocking density affect birds, not only their weights or behaviours but their productivity and mortality as also reported by Turkyilmaz (2006).

The following conclusions were drawn from the research: crude protein and ether extract of the meat were higher at lower stocking densities than higher stocking densities; broilers' weight gains were higher and no weight losses were recorded in 2,800 cm^2 pen during the period of rearing unlike other pens; birds were more comfortable and thrive well for more productivity at maximum stocking density of 4 than any other one and at floor space of 700 cm^2/bird; and mortality rate of broilers increase as stocking density increases.

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